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Arms Races in the Middle East: A Test of Causality

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INTRODUCTION

In recent decades, high levels of military expenditures have characterized the budgetary structures of most Middle Eastern countries.¹ The basic patterns are well known, and for obvious reasons there has been an on-going interest among analysts (a) to explain the militarization of the region as a whole and (b) to search for variables to explain the level of defence spending of the major countries. This latter thrust has focused on factors such as economic conditions, population, size of the country, rivalries, and arms races.

Here, conventional wisdom stresses regional arms races as the prime culprit in accounting for the staggering military burdens, particularly those accrued by Israel, Egypt and Syria. Unfortunately, most of this analysis in this area has been anecdotal at best. In addition, many of the empirical studies of the region's militarization are based on models built largely on arbitrary and often unrealistic assumptions concerning the action/reaction patterns of the major participants.²

The purpose of this paper is to identify from a quantitative perspective the existence of and causation involved in the region's major arms races. To avoid preconceived perceptions and/or biases, the approach is purely atheoretical, and is based on several new statistical developments in the analysis of causation.

DETERMINANTS OF DEFENCE SPENDING

A number of studies have attempted to isolate the factors mainly responsible for militarization in the Third World. The most comprehensive of this is the analysis undertaken by O'Leary³ and Coplin.⁴ They identified seven factors as accounting one way or another for the observed patterns of military expenditures: economic conditions in the country, the role of the military in non-military affairs, internal security needs, reactions to arms purchases by neighbours, budget allocation to service branches in rival states, internal political support, and the age and condition of existing military equipment.

The only apparent correlation was between the military budget and

arms races and the budget levels in rival states. Apparently, both these factors acted as a 'reference point' from which individual countries might set their own budget levels.

Along similar lines, Hill employed a sample of both developed and developing nations in his attempt to synthesize the various approaches used to examine the determinants of defence spending.⁵ Hill was unable to find one 'overriding' factor which could explain a large proportion of the variance of defence spending patterns among the sample set. This led him to conclude that 'the military spending level of any nation is likely to be a product of a number of separate forces',⁶ these include arms races, military alliances, status and rank discrepancies in international systems, military aid, size and wealth of the country, the form of government, the extent of military involvement, internal social friction, and internal political conflict.

The purpose of Westing's paper was 'to present some critical reflections that might prove useful to those concerned with military expenditures and proposals for their reductions'.⁷ In his analysis, he found significant correlations between military expenditures for 159 nations and their respective GNP levels, productive land area, and population.

In an important paper which related defence spending to economic variables, Ames and Goff examined defence and education expenditures in 16 South American countries for the 20 year period between 1948 and 1968.⁸ They found that political variables were not the major determinants of either education or defence budgets; instead, they concluded that changes in the education and defence budgets were related to the level of available resources.

More recently, Maizels and Nissanke examined military spending data for 83 countries.⁹ They hypothesized that the three main determinants of defence spending are the political framework, military activity, and economic linkages. The relative importance of each factor is in turn influenced by national, regional or global conflicts or interactions in the individual country. Using multiple regression analysis, they concluded that:

Domestic factors, particularly the need perceived by ruling elites to repress internal opposition groups, and external factors, including relations with the global power blocs and the availability of foreign exchange to purchase arms from abroad, also appear to be major determinants of government decisions in regard to military expenditures.¹⁰

In 1986, Harris attempted to measure the effect of military expenditures from domestic economic conditions. In doing so, he examined the budgets (since the early 1960s) in five ASEAN countries: Indonesia,

Malaysia, Philippines, Singapore, and Thailand.¹¹ His main findings were:

1. Defence expenditures in the current year are positively correlated with defence spending and the central budgetary position in the previous year.
2. Current defence expenditures have a weak inverse correlation with inflation the previous year.
3. Although current defence budgets are not correlated with the balance of payments in the previous year, the balance of payments affects government revenue which in turn affects defence spending.¹²

In an extension of the Harris paper, Looney and Frederiksen examined the economic determinants of defence expenditures in Latin America. Ten countries were examined using time series data: Argentina, Peru, Mexico, Venezuela, Chile, Paraguay, Uruguay, Colombia, Brazil, and Ecuador.¹³ Four alternative models were tested. The independent variables were current and lagged values of GNP, government expenditure, and military expenditures. It was found that 'a large proportion of variability in defence expenditures can be explained by economic variables; the overall constraint (GDP) and fiscal funding variables . . .'¹⁴

In extending Harris's work on the ASEAN countries, Looney and Frederiksen found three basic patterns: stabilization (Singapore), augmentation (Malaysia), and distributed lags (Philippines). All countries increased defence budgets as expected GNP increased. There were, however, significant variations between countries as to the timing of increased defence allocations. Specifically, Thailand exhibited a weak stabilization pattern. Korean defence expenditure patterns followed a long-run distributed lag function. In the case of Thailand, there was a weak stabilization effect. Indonesia was found to be a special case where resource availability was measured by crude oil production. However, there was a weak augmentation effect as measured by the expected and unexpected rate of inflation.

Clearly, a good case can be made that in the Third World economic variables constrain or at least modify the manner in which defence allocations are undertaken. Clearly the slow-down in military expenditures during the last several years can be traced directly to austerity programmes in countries such as Syria, Egypt and Israel. Saudi Arabia's reduced defence expenditures are also closely related to developments in the international oil markets.

However, in the Middle East factors such as financial assistance from the superpowers, together with hydrocarbon revenues, undoubtedly

buffer many countries from the economic constraints found in other parts of the world. Hence, the analysis below focuses on arms races *per se*.

Here, our purpose is to identify the patterns of causation between the region's major military spenders. In doing so, we hope to contribute to the literature in two respects. First, as is well known, causality tests are, in general, sensitive to lag lengths. The use of shorter lags than actually existed may distort the causal impact of defence expenditures from one country on those of another. On the other hand, relatively long lags may cause the absence of any causality between defence expenditures and economic growth. Few studies have used an 'atheoretical' methodology that allows data themselves to select appropriate lag lengths. Following Hsiao,¹⁵ Akaike's final prediction error (FPE) criterion will be employed to select optimum lag lengths for each variable in each equation.

ALTERNATIVE TESTS FOR CAUSATION

Several statistical tests are available for addressing the issue at hand. To date, the original and most widely used has been the Granger Test.¹⁶

Granger Test

Granger¹⁷ defines causality such that X Granger causes (G-C) Y if Y can be predicted more accurately in the sense of mean square error, with the use of past values of X than without using past X. For example, in assessing the relationship (the same basic formulation would also apply to the arms race between the countries) between defence and economic performance, Granger causality can be specified as:

$$(1) \text{DEFA}(t) = c + \sum_{i=1}^p a(i) \text{DEFA}(t-i) + \sum_{j=1}^q b(j) \text{DEFB}(t-j) + u(t)$$

$$(2) \text{DEFB}(t) = c + \sum_{i=1}^r d(i) \text{DEFB}(t-i) + \sum_{j=1}^s e(j) \text{DEFA}(t-j) + v(t)$$

Where: DEFA is a measure of defence expenditures in country A and DEFB is the corresponding measure for country B; p, q, r and s are lag lengths for each variable in the equation; and u and v are serially uncorrelated white noise residuals. By assuming that error terms (u, v) are 'nice' the specified model is estimated by the ordinary least squares (OLS) method.¹⁸

Within the framework of unrestricted and restricted models, a joint F-test is commonly used for causal detection. The F-statistic would be calculated by:

$$(3) F = \frac{(\text{RSS}(\mathbf{x}) - \text{RSS}(\mathbf{u})) / (\text{df}(\mathbf{x}) - \text{df}(\mathbf{u}))}{\text{RSS}(\mathbf{u}) / \text{df}(\mathbf{u})}$$

where $\text{RSS}(\mathbf{r})$ and $\text{RSS}(\mathbf{u})$ are the residual sum of squares of restricted and unrestricted models, respectively; and $\text{df}(\mathbf{r})$ and $\text{df}(\mathbf{u})$ are, respectively, the degrees of freedom in restricted and unrestricted models.

The Granger test detects causal directions in the following manner. First, unidirectional causality from DEFA to DEFB if the F-test rejects the null hypothesis that past values of DEFA in equation (1) are insignificantly different from zero and if the F-test cannot reject the null hypothesis that past values of DEFA in equation (2) are insignificantly different from zero. That is, DEFA causes DEFB but DEFB does not cause DEFA. Unidirectional causality runs from DEFB to DEFA if the reverse is true. Second, bidirectional causality runs between DEFA and DEFB if both F-test statistics reject the null hypotheses in equations (1) and (2). Finally, no causality exists between DEFA and DEFB if both null hypotheses cannot be rejected at the conventional significance level.

The results of Granger causality tests depend critically on the choice of lag length. If the chosen lag length is less than the true lag length, the omission of relevant lags can cause bias. If the chosen lag is greater than the true lag length, the inclusion of irrelevant lags cause estimates to be inefficient.

While one can choose lag lengths based on preliminary partial autocorrelation methods, there is no *a priori* reason to assume lag lengths equal for all of our sample countries. For example in a different context – a study of causation between defence expenditures and growth in the Philippines – Frederiksen and LaCivita¹⁹ found no statistical relationship between growth and defence when both variables were entered in the estimating equation with a lag equal to four. When the lag length was changed to two periods, however, it was found that growth caused defence. Since both lag lengths were chosen arbitrarily, one cannot say which is preferred.

The Hsiao Procedure

To overcome the difficulties noted above, Hsiao²⁰ has developed a systematic method for choosing lag lengths for each variable in an equation. Hsiao's method combines Granger Causality and Akaike's final prediction error (FPE) defined as the (asymptotic) mean square prediction error, to determine both the optimum lag for each variable and causal relationships. In a paper examining the problems encountered

in choosing lag lengths, Thornton and Batten²¹ found Hsiao's method to be superior to both arbitrary lag length selection and several other systematic procedures for determining lag length.

The first step in Hsiao's procedure is to perform a series of autoregressive regressions on the dependent variable. In the first regression, the dependent variable is lagged once. In each succeeding regression, one more lag on the dependent variable is added. That is we estimate M regressions of the form:

$$(4) \text{DEF}(t) = a + \sum_{i=1}^m b_i(t-1) \text{DEF}(t-1) + e_i(t)$$

Where the values of m range from 1 to M . For each regression, we compute the FPE in the following manner:

$$(5) \text{FPE}(m) = \frac{T + m + 1}{T - m - 1} \text{ESS}(m) / T$$

Where T is the sample size, and $\text{FPE}(m)$ and $\text{ESS}(m)$ are the final prediction error and the sum of squared errors, respectively. The optimal lag length, m^* , is the lag length which produces the lowest FPE. Once m^* has been determined, regressions are estimated with the lags on the other variable added sequentially in the same manner used to determine m^* . Thus we estimate four regressions of the form:

$$(6) \text{DEFA}(t) = a + \sum_{i=1}^{m^*} b_i(t-1) \text{DEAF}(t-1) + \sum_{i=1}^n c_i(t-1) \text{DEFB}(t-1) + e_i(t)$$

with n ranging from one to four. Computing the final prediction error for each regression as:

$$\text{FPE}(m^*, n) = \frac{T + m^* + n + 1}{T - m^* - n - 1} \text{ESS}(m^*, n) / T$$

we choose the optimal lag length for D , n^* as the lag length which produces the lowest FPE. Using the final prediction error to determine lag length is equivalent to using a series of F -tests with variable levels of significance.²²

The first term measures the estimation error and the second term measures the modelling error. The FPE criterion has a certain optimality property that 'balances the risk due to bias when a lower order is selected and the risk due to increases in the variance when a higher order is selected'.²³ As noted by Judge et al.,²⁴ an intuitive reason for using the

FPE criterion is that longer lags increase the first term but decrease the RSS of the second term, and thus the two opposing forces are balanced optimally when their product reaches its minimum.

Again using the example of defence expenditures in country A and B, four cases are possible:

(a) **defence(A) causes defence(B)** – occurring when the prediction error for defence expenditures in country B is reduced when defence expenditures in country A is added to the equation. In addition, when defence expenditures in country B are added to the country A defence equation, that equation's final prediction error increases;

(b) **defence (B) causes defence (A)** – occurring when the prediction error of country B's defence equation increases when defence in country A's defence is added to the equation, and is reduced when country B's defence is added to the regression equation for country A's defence;

(c) **feedback** – occurring when the final prediction error decreases when defence in country A is added to country B's defence equation, and the final prediction error decreases when defence in country B is added to country A's defence equation; and

(d) **no relationship** occurs when the final prediction error increases when defence in A is added to B's defence equation, and also increases when defence B is added to country A's defence equation.

METHODOLOGY

The data for military expenditures used to carry out the Hsiao test were compiled from the Stockholm International Peace Research Institute, *SIPRI Yearbook, World Armaments and Disarmament*. Two alternative measures of defence burden were used: (a) constant price defence expenditures and (b) the defence burden, the share of defence in Gross Domestic Product (GDP). When consistent price deflators were not available the defence expenditure term was specified only in terms of the growth of the defence burden.

Before the tests were performed, one statistical problem needed to be addressed. It is widely known that most economic time series are non-stationary. As indicated by Judge et al.,²⁵ 'stationary is an important property as it guarantees that there are no fundamental changes in the structure of the process that would render prediction difficult or impossible'. In order to remove all possible non-stationarities, real defence expenditures and the defence burden were transformed to rates of growth. When these transformed series were regressed on a constant and time, their coefficients on time were insignificantly different from

TABLE 1
MIDDLE EAST ARMS
RACES: ISRAEL, COUNTRY CAUSALITY TESTS

(final prediction error)

<i>Dependent Var</i> <i>Independent Var</i> <i>Optimum Lag</i> <i>Sign ()</i>	<i>Israel Def</i> <i>Israel Def</i>	<i>Israel Def</i> <i>Other Def</i>	<i>Other Def</i> <i>Other Def</i>	<i>Other Def</i> <i>Israel Def</i>
<i>Israel/Saudi Arabia (Growth in Defence Expenditures)</i>				
1966-1987	402.62	308.36	650.26	690.37
(Arabia→Israel)	3 years	3 years	3 years	3 years
	(+)	(+)	(+)	(+)
r2	0.366	0.637	0.320	0.461
<i>Israel/Saudi Arabia (Growth in Defence Burden)</i>				
1966-1987	373.77	349.99	618.99	603.06
(Feedback)	1 year	3 years	4 years	2 years
	(+)	(+)	(-)	(+)
r2	0.133	0.387	0.466	0.573
<i>Israel/Syria (Growth in Defence Expenditures)</i>				
1955-1987	488.84	517.59	937.58	903.78
(Israel→Syria)	1 year	1 year	1 year	3 years
	(+)	(-)	(-)	(+)
r2	0.162	0.165	0.033	0.225
<i>Israel/Syria (Growth in Defence Burden)</i>				
1966-1987	373.77	401.01	615.42	594.28
(Israel→Syria)	1 year	1 year	1 year	1 year
	(+)	(-)	(-)	(+)
r2	0.133	0.152	0.086	0.195
<i>Israel/Syria (Growth in Defence Burden)</i>				
1962-1987	329.17	348.65	518.13	491.18
(Israel→Syria)	1 year	1 year	1 year	1 year
	(+)	(-)	(-)	(+)
r2	0.118	0.136	0.078	0.191
<i>Israel/Egypt (Growth in Defence Expenditures)</i>				
1962-1987	362.96	352.20	609.49	543.18
(Feedback)	3 years	1 year	1 year	4 years
	(+)	(-)	(+)	(+)
r2	0.330	0.340	0.032	0.371

TABLE 2
MIDDLE EAST ARMS
RACES: SAUDI ARABIA, COUNTRY CAUSALITY TESTS

(final prediction error)

<i>Dependent Var</i> <i>Independent Var</i> <i>Optimum Lag</i> <i>Sign ()</i>	<i>Arabia Def</i> <i>Arabia Def</i>	<i>Arabia Def</i> <i>Other Def</i>	<i>Other Def</i> <i>Other Def</i>	<i>Other Def</i> <i>Arabia Def</i>
<i>Saudi Arabia/Iran (Growth in Defence Expenditures)</i>				
1966-1985	712.22	701.31	1049.16	1144.18
(Iran→Arabia)	3 years	1 year	3 years	4 years
	(+)	(+)	(+)	(+)
r2	0.291	0.372	0.404	0.581
<i>Saudi Arabia/Jordan (Growth in Defence Burden)</i>				
1966-1987	618.99	671.63	518.20	453.94
(Arabia→Jordan)	4 years	3 years	1 year	1 year
	(-)	(+)	(+)	(+)
r2	0.466	0.570	0.001	0.202
<i>Saudi Arabia/Egypt (Growth in Defence Burden)</i>				
1966-1987	618.99	601.51	770.95	735.22
(Feedback)	4 years	2 years	1 year	3 years
	(-)	(+)	(+)	(+)
r2	0.466	0.574	0.101	0.352
<i>Saudi Arabia/Syria (Growth in Defence Burden)</i>				
1966-1987	618.99	510.24	615.42	673.20
(Syria→Arabia)	3 years	2 years	1 year	1 year
	(-)	(+)	(-)	(+)
r2	0.466	0.638	0.086	0.088

zero for all countries. Similar regressions of the untransformed levels indicated the presence of a trend.

The results for the causality analysis of the regional arms races together with the direction of country causation are presented with the final prediction error (FPE), the coefficient of determination (r2), together with the optimal lag. For simple organizational convenience the results are presented in terms of:

- (a) Arms races involving Israel (Table 1);
- (b) those involving Saudi Arabia (but not Israel – Table 2); and
- (c) other regional arms races (Table 3).

It should be noted that if a country is not listed it is because no statistically significant military expenditure patterns were found *vis à*

TABLE 3
MIDDLE EAST ARMS
RACES: SYRIA, ALGERIA COUNTRY CAUSALITY TESTS

(final prediction error)

<i>Dependent Var</i> <i>Independent Var</i> <i>Optimum Lag</i> <i>Sign ()</i>	<i>Syrian Def</i> <i>Syrian Def</i>	<i>Syrian Def</i> <i>Other Def</i>	<i>Other Def</i> <i>Other Def</i>	<i>Other Def</i> <i>Syrian Def</i>
<i>Syria/Turkey (Growth in Defence Burden)</i>				
1962-1986	492.36	516.44	179.31	146.73
(Syria→Turkey)	1 year	1 year	3 years	2 year
	(-)	(-)	(-)	(+)
r2	0.121	0.150	0.197	0.444
<i>Syria/Egypt (Growth in Defence Expenditures)</i>				
1962-1987	667.50	618.96	609.49	658.66
(Egypt→Syria)	1 year	2 years	1 year	1 year
	(+)	(+)	(-)	(-)
r2	0.001	0.206	0.032	0.032
<i>Dependent Var</i> <i>Independent Var</i> <i>Optimum Lag</i> <i>Sign ()</i>	<i>Algeria Def</i> <i>Algeria Def</i>	<i>Algeria Def</i> <i>Other Def</i>	<i>Other Def</i> <i>Other Def</i>	<i>Other Def</i> <i>Algeria Def</i>
<i>Algeria/Morocco (Growth in Military Expenditures)</i>				
1967-1986	554.11	576.99	265.64	203.62
(Algeria→Morocco)	1 year	1 year	1 year	4 years
	(+)	(+)	(+)	(+)
r2	0.002	0.052	0.149	0.571
<i>Algeria/Morocco (Growth in Military Burden)</i>				
1967-1986	562.44	627.86	247.75	144.92
(Algeria→Morocco)	1 year	1 year	2 years	2 years
	(-)	(+)	(+)	(+)
r2	0.003	0.043	0.212	0.625

vis its neighbours. For example, military expenditures in Libya do not cause or are not affected by those in Israel or neighbouring North African countries.

The causality analysis produced several interesting findings, the most significant of which relate to Israel (Table 1):

1. Not surprisingly, Israel interacts militarily with by far the greatest

number of countries in the region. However, contrary to conventional wisdom, Israel appears to initiate many of the regional arms races.

2. Defence expenditures in Israel stimulate (with a one year lag) those in Syria. Syrian defence expenditures do not appear to affect Israeli decisions concerning allocations to the military.
3. Increases in Israeli defence expenditures cause Egypt to increase (with a three year lag) its defence expenditures. However, increases in Egyptian allocations to the military actually cause a decline in Israeli defence expenditures.
4. Israel and Saudi Arabia appear engaged in a mini-arms race, with increases in the defence burden in each country responded to (with a three year lag) by an increase in that of the other.

Again, contrary to conventional wisdom, Saudi Arabian defence expenditures are not passive adjustments to changes in defence allocations in neighbouring countries. In addition to its arms race with Israel, Saudi Arabian defence expenditures interact with those in Egypt. Several other patterns are also in evidence (Table 2):

1. While not affected by Iraqi defence expenditures, Saudi Arabian defence expenditures respond to those in Iran (but not vice versa).
2. Defence expenditures in Jordan are affected by Saudi allocations to the military (but not vice versa).
3. Increases in Syrian defence burdens also stimulate (but not vice versa) adjustments upward in the Saudi defence burden.
4. Interestingly enough, in addition to Saudi Arabia, Iraq's defence expenditures do not appear to be caused by, or to affect, those of its neighbours.

Perhaps the most complex patterns involve Syria and its neighbours (Table 3):

1. In addition to affecting allocations to defence in Saudi Arabia, increases in Syrian defence expenditures produce a similar response in Turkey.
2. While increases in Israeli defence expenditures produce a similar adjustment in Syria, those in Egypt do the same, but with a much shorter lag.

The only other major pattern in the region involves Algeria and Morocco, with Algerian defence expenditures affecting Moroccan military expenditures with a two or four year lag depending on whether one looks at the growth in the defence burden or in military expenditures.

CONCLUSIONS

The findings presented above represent a first step in identifying the causal interactions between the major Middle East combatants. Additional work should be undertaken to control for factors other than arms races *per se*. In this regard, there is always the possibility that defence expenditures in say, Jordan or Egypt (which receive economic assistance from Saudi Arabia) may simply reflect Saudi oil revenues and not Saudi defence expenditures. On the other hand, it is unlikely these considerations would alter the main finding of the study: suppressing increases in Israeli defence expenditures is the most effective way of reducing militarization in the region.

NOTES

1. Unless otherwise specified, military expenditure data are from Stockholm International Peace Research Institute, *SIPRI Yearbook*, (New York: Oxford University Press), various issues. Price deflators are from the International Monetary Fund, *International Financial Statistics Yearbook*, various issues.
2. For an excellent critique of the literature, see Jean-Christian Lambelet, 'The Formal "Economic" Analysis of Arms Races: What - If Anything - Have We Learned Since Richardson?', *Conflict Management and Peace Science* (Spring 1986), pp. 1-18.
3. Michael K. O'Leary and William D. Coplin, *Quantitative Techniques in Foreign Policy Analysis and Forecasting* (New York: Praeger Publishers, 1975).
4. Other major studies are surveyed in Robert E. Looney, 'Factors Underlying Venezuelan Defense Expenditures', *Arms Control* (1986); and Robert E. Looney 'Military Expenditures in Latin America: Budgetary Tradeoff Analysis', *Journal of Economic Development* (July 1986), pp. 69-103.
5. Kim Quaile Hill, 'Domestic Politics, International Linkages, and Military Expenditures', *Studies in Comparative International Development* 13 (Spring 1978). This article provides an excellent review of the literature prior to 1978.
6. *Ibid.*, p. 53.
7. Arthur H. Westing, 'Military Expenditures and their Reduction', *Bulletin of Peace Proposals*, 9 (1978), pp. 24-29.
8. Barry Ames and Ed Goff, 'Education and Defense Expenditures in Latin America: 1948-68', in Craig Liske, William Loehr and John McCamant (eds.) *Comparative Public Policy: Issues, Theories and Methods*, (New York, John Wiley and Sons, 1975).
9. Alfred Maizels and Machiko K. Nissanke, 'The Determinants of Military Expenditures in Developing Countries', *World Development* 14 (1986) pp. 1125-40. See also Alfred Maizels and Machiko Nissanke, 'The Causes of Military Expenditure in Developing Countries', in Deger and West, *Defence, Security and Development*, pp. 129-39.
10. *Ibid.*, p. 1137.
11. Geoffrey Harris, 'The Determinants of Defence Expenditure in the ASEAN Region', *Journal of Peace Research*, 23 (1986), pp. 41-9.
12. *Ibid.*, p. 46. For an excellent survey article, see G.T. Harris, 'Economic Aspects of Military Expenditure in Developing Countries: A Survey Article', *Contemporary Southeast Asia*, 10 (June 1988), pp. 82-102.

13. Robert E. Looney and Peter C. Frederiksen, 'Economic Determinants of Latin American Defense Expenditures', *Armed Forces and Society*, 14 (Spring 1988), pp. 49–471.
14. *Ibid.*, p. 468.
15. C. Hsiao, 'Causality Tests in Econometrics', *Journal of Economic Dynamics and Control* (1979), pp. 321–46; and C. Hsiao 'Autoregressive Modeling and Money Income Causality Detection', *Journal of Monetary Economics* (1981), pp. 85–106.
16. For a critique of these methods see Charles J. LaCivita and Peter C. Frederiksen, 'Defense Spending and Economic Growth: An Alternative Approach to the Causality Issue', *Journal of Developing Economies* (forthcoming). The analysis here follows that taken by LaCivita and Frederiksen
17. C.W.J Granger, 'Investigating Causal Relations by Econometric Models and Cross-Spectral Methods', *Econometrica* (1969), pp. 424–38.
18. If the disturbances of the model were serially correlated, the OLS estimates would be inefficient, although still unbiased, and would distort the causal relations. The existence of serial correlation was checked by using a maximum likelihood correlation for the first-order autocorrelation of the residuals (AR(1)). The comparison of both OLS and AR(1) results indicated that no significant changes appeared in causal directions. Therefore, we can conclude 'roughly' that serial correlation was not serious in this model.
19. P.C. Frederiksen and C.J. LaCivita, 'Defense Spending and Economic Growth: Time Series Evidence on Causality for the Philippines, 1956–1982', *Journal of Philippine Development* (Second Semester 1987), pp. 354–60.
20. C. Hsiao, 'Autoregressive Modeling and Money-Income Causality Detection', *Journal of Monetary Economics* (1981), pp. 85–106.
21. D.L. Thornton and D.S. Batten, 'Lag-length Selection and Tests of Granger Causality Between Money and Income', *Journal of Money, Credit and Banking* (1985), pp. 164–78.
22. Since the F statistic is redundant in this instance they are not reported here. They are, however, available from the author upon request.
23. C. Hsiao, 'Causality Tests in Econometrics', *Journal of Economic Dynamics and Control* (1979), p. 326.
24. G.G. Judge, W. Hill, H. Griffiths, H. Lutkepohl and T.C. Lee, *Introduction to the Theory and Practice of Econometrics* (New York: John Wiley and Sons, 1982).
25. *Ibid.* p. 671.